U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 131.
A. C. TRUE, Director.

PLANS OF STRUCTURES

IN USE ON

IRRIGATION CANALS IN THE UNITED STATES.

From drawings exhibited by the Office of Experiment Stations at Paris in 1900 and at Buffalo in 1901.

PREPARED UNDER THE DIRECTION OF
ELWOOD MEAD,
CHIEF OF IRRIGATION INVESTIGATIONS.

WASHINGTON:
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1903.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 6, 1903.

SIR: I have the honor to submit for publication a bulletin giving detailed plans and estimates of a number of structures built as a part of the irrigation works in different parts of the arid region of the United States during the past twenty years. These drawings and the notes as to their cost, durability, and usefulness have been prepared under the supervision of Prof. Elwood Mead, chief of the irrigation investigations of this Office.

It is believed that this information will be of practical value to engineers and others interested in the construction and operation of irrigation works, and its publication as a bulletin of this Office is recommended.

Respectfully,

A. C. TRUE, *Director.*

Hon. JAMES WILSON, *Secretary of Agriculture.*

ILLUSTRATIONS.

		Page.
PLATE I.	Head gates of Consolidated Canal, Salt River Valley, Arizona	9
II.	Head gates of Amity Canal, Colorado	11
III.	Drop in Comanche Canal, Colorado	13
IV.	Waste and regulating gates of Kicking Bird Canal, Colorado	15
V.	Rating flume of Kicking Bird Canal, Colorado	17
VI.	Outlet gates of Neeskah Reservoir, Colorado	19
VII.	Gageby Arroyo waste way, Colorado	21
VIII.	Gageby Arroyo waste way, Colorado	23
IX.	Head gates of Grand Valley Canal, Colorado	25
X.	Flume No. 7, main line Grand Valley Canal, Colorado	27
XI.	Flume No. 7, main line Grand Valley Canal, Colorado	29
XII.	Head gates of La Junta and Lamar canals, Colorado	31
XIII.	Head gates and metal work details of Montrose Canal, Colorado	33
XIV.	Head gates of Sonora and Sinaloa canals, Mexico	35
XV.	Lifting apparatus for the head gates of Sonora and Sinaloa canals, Mexico	37
XVI.	Outlet gates of McMillan Reservoir, Carlsbad, New Mexico	39
XVII.	Dam of Bear River Canal, Utah	41
XVIII.	Lifting apparatus for head gates of the Bear River Canal, Utah	43
XIX.	Aqueduct over Malade River, Bear River Canal, Utah	45
XX.	Weir for measuring water furnished by Jordan and Salt Lake City Canal in exchange for water of Parleys Creek, Utah	47
XXI.	Penstock and waste way of West Side Canal, Wyoming and Colorado	49
XXII.	Laybourn iron flume	51

IRRIGATION STRUCTURES.

INTRODUCTION.

At the Paris Exposition in 1900 the Office of Experiment Stations exhibited a series of drawings giving detailed plans of a number of structures then in use on irrigation works in various parts of the arid region of the United States. The purpose of this exhibit was to illustrate engineering practice in the West, and the attention it received abroad and, later, in this country when exhibited at Buffalo in 1901, led to the belief that such of these as could be readily reproduced had sufficient practical value to be worthy of this being done, thus making them available for engineers and others interested in irrigation structures. The illustrations in this bulletin are taken from those drawings, and the facts regarding their cost, durability, and success have been gathered from correspondence with the owners of the works of which they form a part. It is believed that their publication at this time will furnish to young engineers plans which have been tested in practice and suggestions as to improvements in these plans, while to older engineers the records of durability will aid in determining whether or not the large use of wood as material in irrigation structures can wisely be continued under existing conditions. There are certain facts which indicate that the use of timber in irrigation structures, which formerly prevailed, must in time give way to the use of more durable materials. Wooden structures were a conspicuous feature of earlier irrigation works because timber was abundant and cheap. Masonry and concrete were avoided because both labor and cement were dear. But for several years timber has been constantly rising in price, while the cost of masonry has in many sections been greatly reduced. It is now the belief of many engineers that when durability and expense of repairs are taken into account, permanent structures are the most economical. The information given in the notes which accompany these plates as to the original cost, cost of maintenance, and present condition of these structures is not as complete as it was hoped to make it, but they seem to show that ten years is apparently as long as wooden structures can be relied upon, although some of those illustrated have been in use for twice that period. It is hoped that these records of service will aid engineers in making plans for the works to be built in the era of rapid development upon which we now appear to be entering.

HEAD GATES OF CONSOLIDATED CANAL, SALT RIVER VALLEY, ARIZONA.

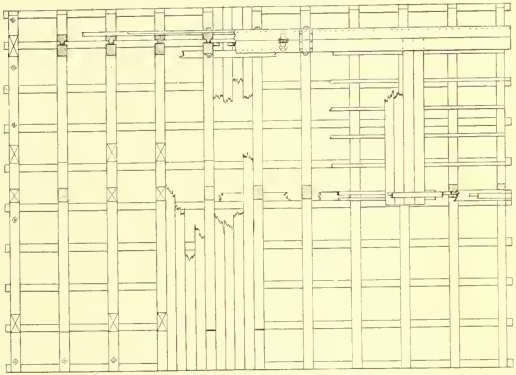
[PLATE I.]

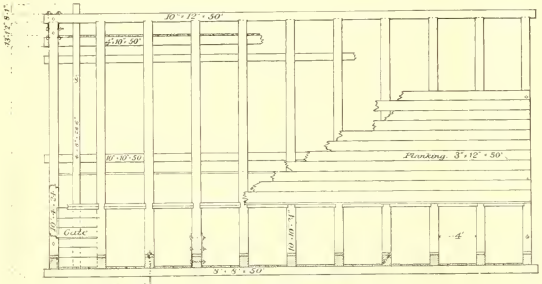
The Consolidated Canal has a capacity of 1,000 cubic feet of water per second. The head gate was built large enough to take in this volume when the river was low, and strong enough to withstand the pressure of floods, which sometimes discharge 100,000 cubic feet per second. The greatest depth of water on the gates thus far has been 20 feet. They are operated without difficulty against this pressure. Masonry cost $4 per cubic yard; concrete work, $5 per cubic yard, with cement furnished by the company at a cost of $6.65 per barrel, 330 barrels being used. Lumber cost $44 per 1,000 feet B. M., and common labor $1.75 per day. The total cost of construction was $13,653. The dam has been in use about eight years, and both timber and masonry are in excellent condition.

Bill of lumber and iron.

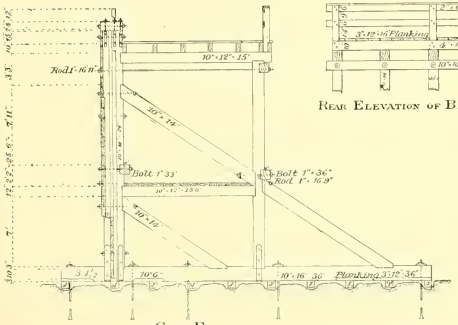
Lumber.		Iron.		
Number of pieces.	Dimensions.	Articles.	Pieces.	Dimensions.
11	10″ by 16″ by 36′	Machine bolts	33	1″ by 28″.
11	10″ by 14″ by 24′	Do	11	1″ by 26″.
11	10″ by 10″ by 24′	Do	11	1″ by 33″.
11	10″ by 14″ by 32′	Do	33	1″ by 36″.
10	8″ by 8″ by 30′	Do	165	1″ by 12″.
10	8″ by 8″ by 20′	Anchor bolts	55	1¼″ by 6′ 6″.
6	10″ by 10″ by 26′	Eagle bolts	16	⅝″ by 13″.
11	10″ by 14″ by 34′	Do	300	⅜″ by 6½″.
11	10″ by 12″ by 30′	Do	520	½″ by 5½″.
2	10″ by 14″ by 26′	Do	100	$\frac{7}{16}$″ by 8½″.
2	10″ by 12″ by 26′	Do	375	$\frac{7}{16}$″ by 7½″.
12	4″ by 10″ by 26′	Do	200	½″ by 8″.
2	3″ by 10″ by 26′	Bolt ends	66	1″ by 14″.
2	6″ by 8″ by 22′	Do	44	1″ by 9″.
1	6″ by 6″ by 26′	Drift bolts	132	1″ by 1″ by 20″.
10	4″ by 8″ by 28′	Do	143	⅝″ by ⅝″ by 12″.
4	4″ by 4″ by 20′	Plate washers	55	5″ by 5″ by ⅝″ for 1¼″ bolt.
5	4″ by 6″ by 34′	Do	225	4″ by 4″ by $\frac{7}{16}$″ for 1″ bolt.
15	3″ by 12″ by 18′	Bolt washers	600	⅜″.
50	3″ by 12″ by 16′	Do	950	$\frac{7}{16}$″.
40	3″ by 12″ by 36′	Iron bars	10	½″ by 2½″ by 16′.
12	3″ by 12″ by 20′	Do	36½	¼″ by 6″ by 16′.
12	3″ by 12″ by 30′	Do	5	¼″ by 7″ by 16′.
20	2″ by 12″ by 20′	Do	22	1″ round.
20	2″ by 12″ by 30′	Ship spikes	400	½″ by 5″.
6	2″ by 6″ by 26′	Do	600	⅜″ by 7½″.
		Nails	100	30 d.
		Do	200	60 d.
		Do	10	10 d.
		Do	10	12 d.
		Do	5	8 d.

TOP VIEW.

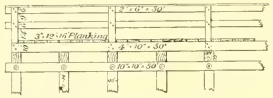




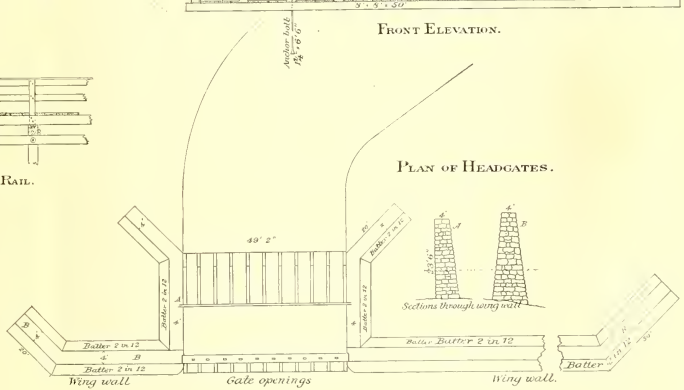
FRONT ELEVATION.



SIDE ELEVATION.



REAR ELEVATION OF BRIDGE RAIL.

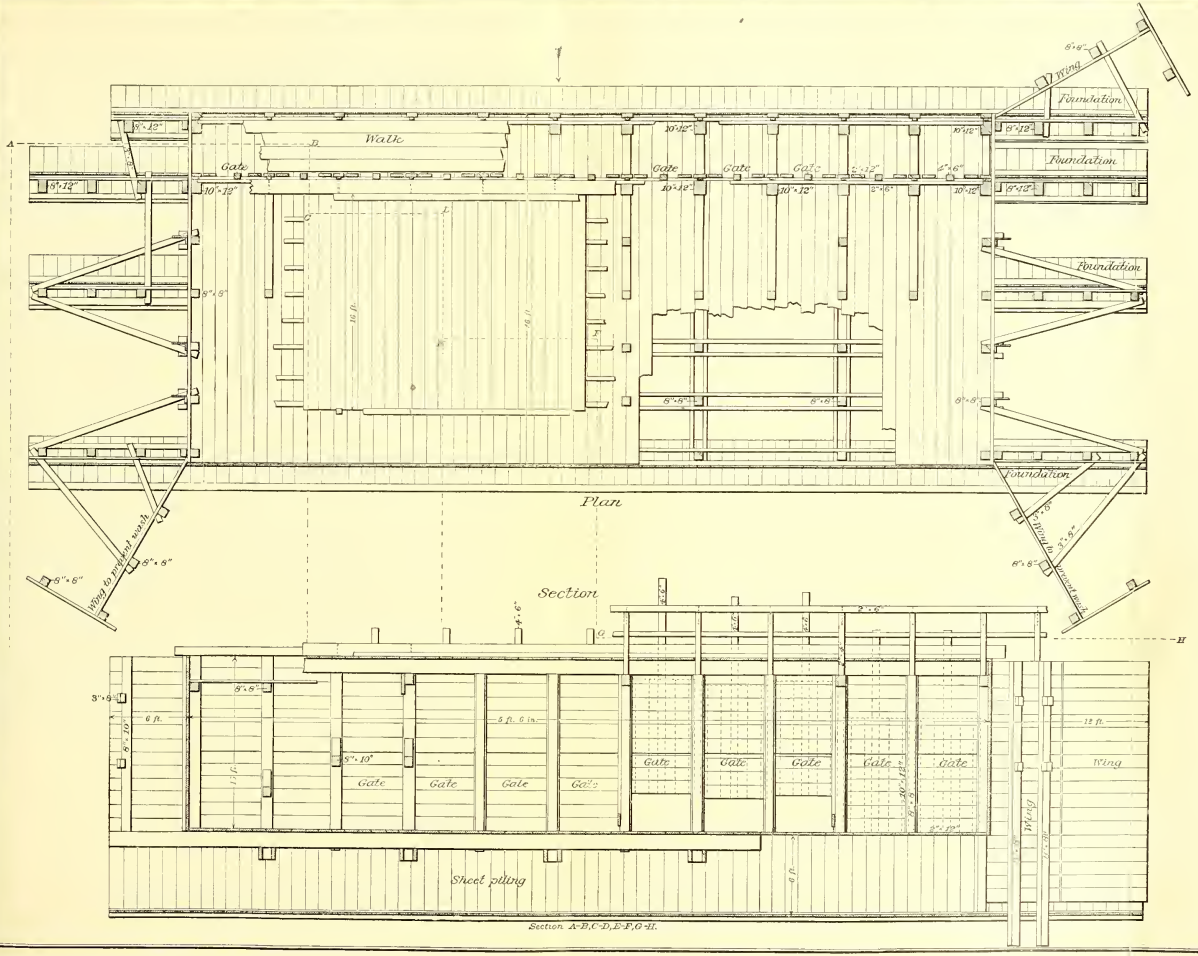


PLAN OF HEADGATES.

HEAD GATES OF AMITY CANAL, COLORADO.

[Plate II.]

The Amity Canal takes water from the Arkansas River in southern Colorado. The head gate was built in the winter of 1893 and cost approximately $3,500. In the ten years since its construction it has required very few repairs. It is being replaced this year by a concrete and masonry structure, but if it had not been for the washing out of the dam in front of it about a year ago it would have served for two or three years more. At the time of its removal the wings had become considerably decayed. The eleven gate openings were each 4 feet 6 inches wide in the clear, and arrangements for operating them proved satisfactory and serviceable.



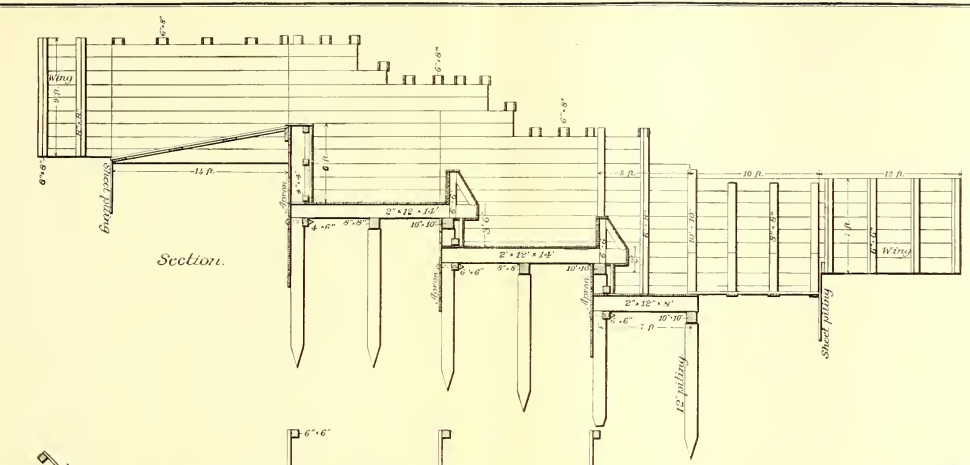
HEAD GATES OF AMITY CANAL, COLORADO.

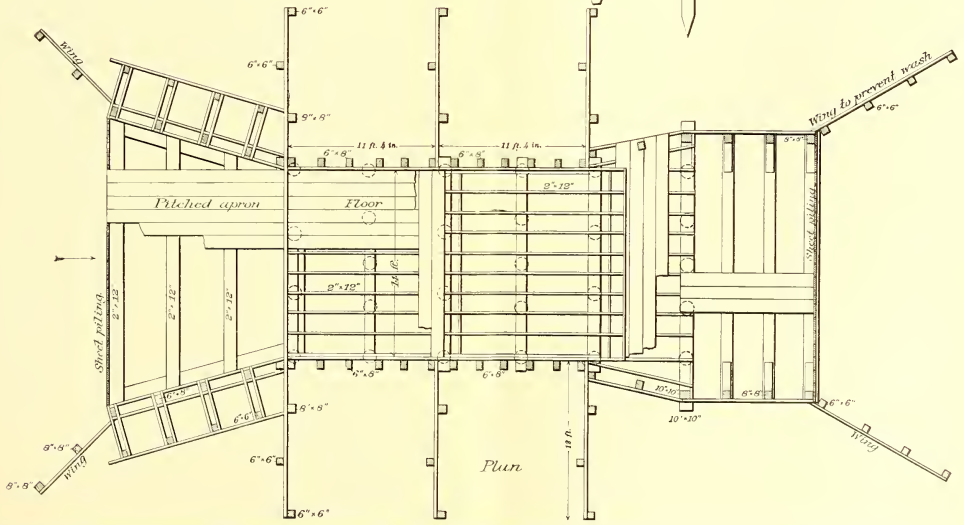
DROP IN COMANCHE CANAL, COLORADO.

[PLATE III.]

This drop was built in 1899 in the Comanche Canal, the outlet canal from the reservoirs of the Arkansas Valley Sugar Beet and Irrigated Land Company, and has been in operation each year as the demand for reservoir water was supplied. There are, in all, eight drops of this plan on the Comanche Canal. The discharge of the canal is 400 cubic feet per second. In consideration of the fact that these drops are in operation only on an average of about three months in each year the chances for leakage when water is first turned in are very great. To overcome the effects of exposure to the sun and warping of timbers the floors and sides of the chambers have in some cases been doubled and all joints calked with oakum, and in the case of three of the drops the planking was grooved on both edges and tongues inserted. In the drops where the planking was doubled practically no trouble has arisen from leakage however long at a time water has been out of the canal. In the case of the three drops with grooved-and-tongued planking the shrinkage in the planking was so great that a great deal of leakage resulted. This may have been due, in some measure, to the condition of the lumber. To the underside of the cross braces of the side posts of these three drops a wooden ceiling has been spiked to protect the structure from the sun and also to prevent spray flying in windy weather. The effect of the cover has been beneficial. All drops are now working satisfactorily. Their life without considerable repairs and renewal of timbers in contact with the earth is placed by the engineer of the company at six years.

The average cost of the drops per foot vertical was about $125. Considering the life of such structures and comparing their cost with that of concrete drops, there is no sound argument in favor of the use of timber. The company has made designs for armored concrete drops for the last mile of the Comanche Canal and expects to commence the construction of these soon.





DROP IN COMANCHE CANAL, COLORADO.

WASTE AND REGULATING GATES OF KICKING BIRD CANAL, COLORADO.

[PLATE IV.]

The Kicking Bird Canal is one of the large canals for diverting and distributing the Arkansas River in southern Colorado. These gates are located about one mile from the end of the canal on the shores of Lake Neegronda, an artificial reservoir. They were originally intended as a safeguard to the inlet of a structure known as the Neegronda inlet chute, which is an inclined wooden flume built on piles and leading into the Neegronda Reservoir. Built of wood and subjected the greater part of the year to the drying effects of winds and sun, the flooring and side boards of the chute became more or less distorted. Owing to its steep grade, a small leak could easily cause serious damage, if not the complete wreck of the flume. The waste gate was provided as a means of safely emptying the canal into another reservoir in case of such leaks or during times when the chute required repairs.

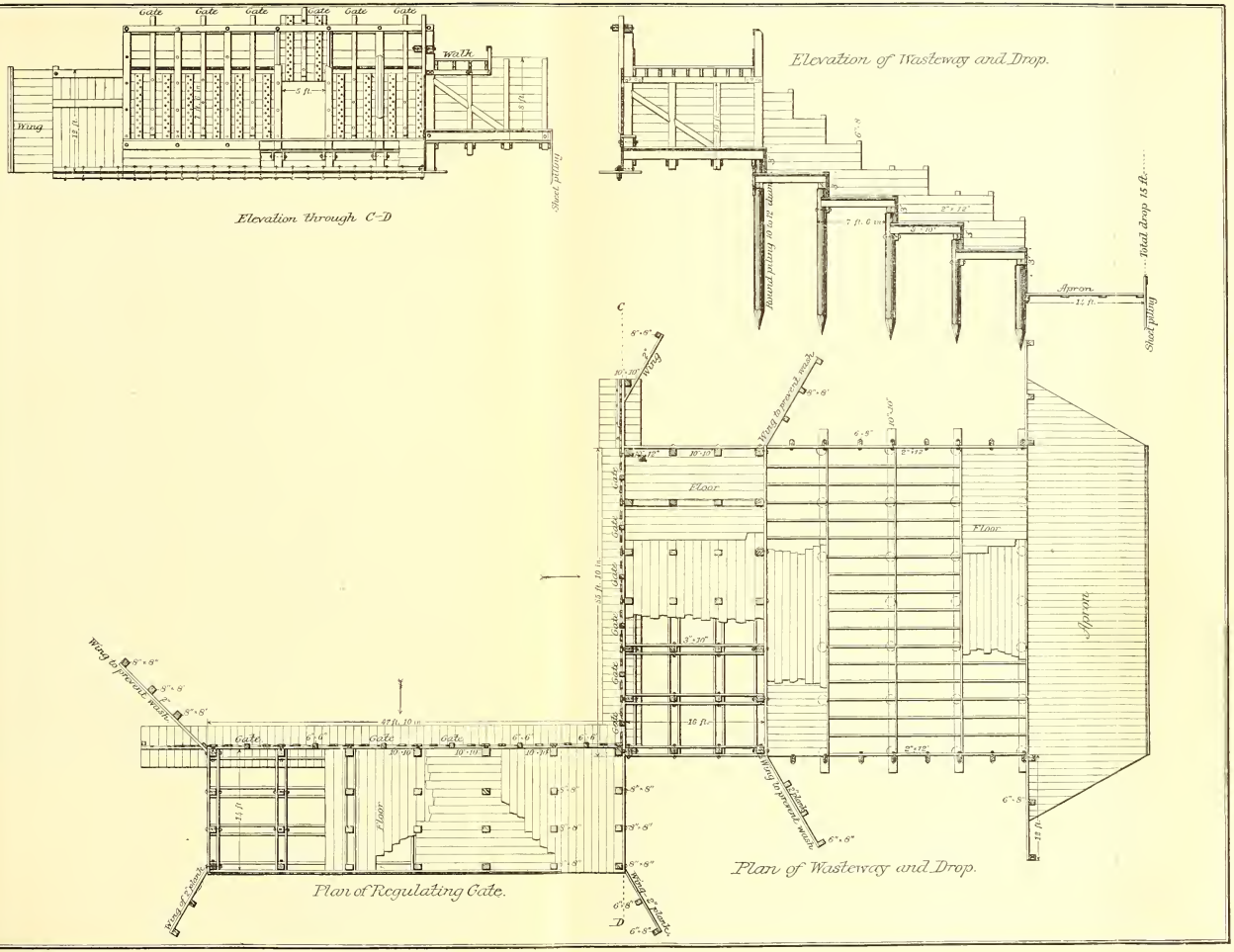
Since the gates were built, in 1899, a branch canal, the Lone Wolf, has been built to convey water directly into another reservoir belonging to this canal system, known as the Neenoshe. This canal heads at this waste gate, the name of which has been changed and is now known as Division Gate No. 3. When the gates were constructed, the ground was perfectly dry and difficult to tamp. Earth mixed with manure was tamped beneath the wings and under the floors. There was a great deal of trouble when the water was first turned in, but since then no such trouble has been experienced. The structure is at present in good condition, and will not require renewal for five or six years.

The cost of the gates was $2,000. The prices of materials at Lamar, 20 miles distant from the works, were as follows:

Yellow pine lumber	per M..	$20.50
Native lumber	do....	16.00
Spruce piling	per linear foot..	.14
Nails	per 100 pounds..	2.75
Machine bolts	do....	3.00

The rates of wages were:

Man and team	per day..	$3.00
Laborers	do....	1.60
Carpenters	do....	2.50

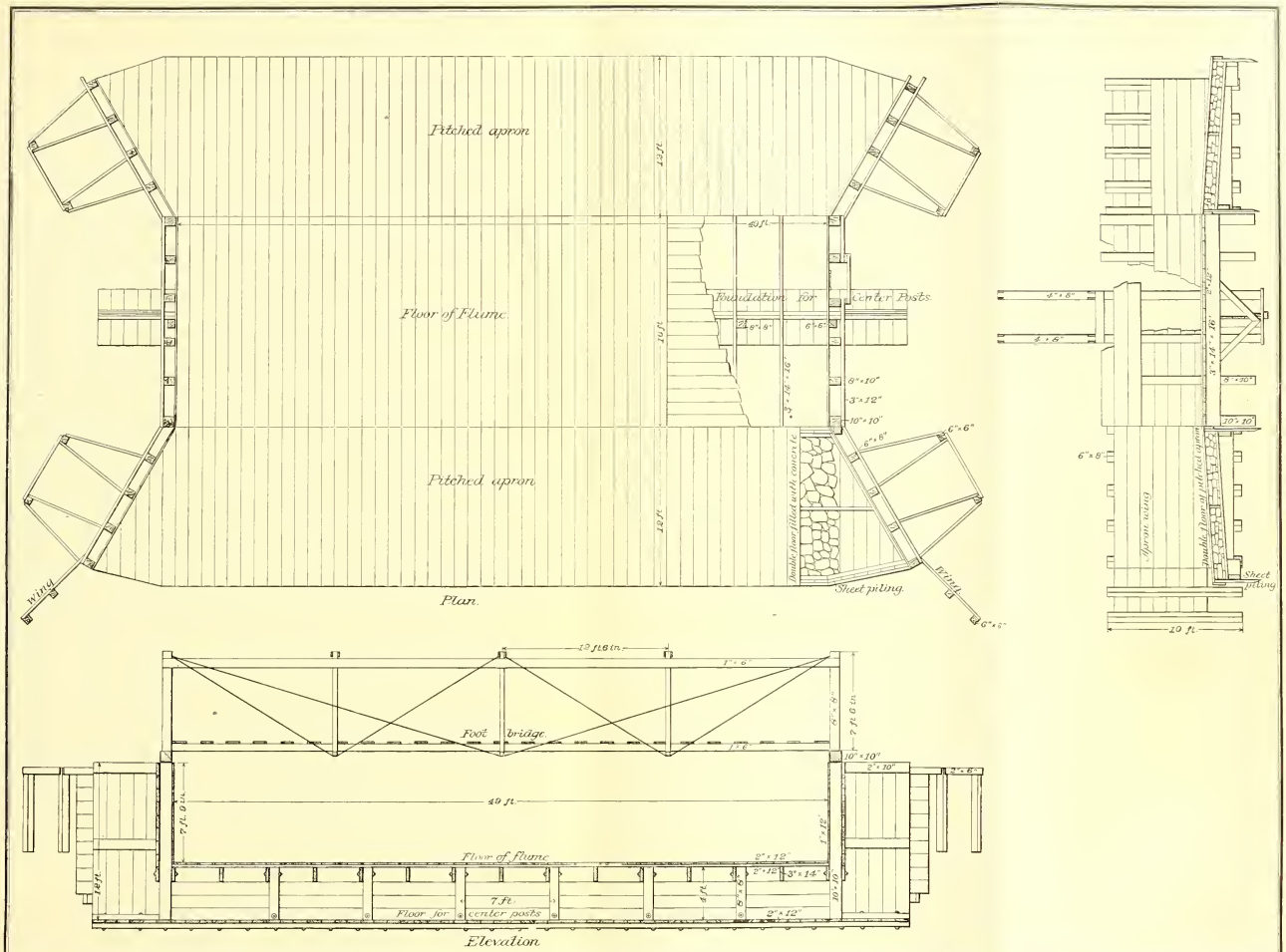


WASTE AND REGULATING GATES OF KICKING BIRD CANAL, COLORADO.

RATING FLUME OF KICKING BIRD CANAL, COLORADO.

[Plate V.]

The rating flume of the Kicking Bird Canal was designed to secure an accurate record of the flow of water. It was built in 1899, and the prices given for materials and labor in the construction of the waste gates of this canal prevailed in its construction. The total cost was $810. The materials of the light footbridge, being exposed to the elements, soon became warped to such a degree that the bridge was unsafe, and in the spring of 1901 it was taken down and replaced by four light king-post trusses with support midway between the sides of the flume. The flume is now in good condition and has been satisfactory in service. There are 19,500 feet of lumber in the structure.



RATING FLUME OF KICKING BIRD CANAL, COLORADO.

OUTLET GATES OF NEESKAH RESERVOIR, COLORADO.

[PLATE VI.]

The Neeskah Reservoir is located in Kiowa County, Colo., near the southern boundary of that county, and about 32 miles west of the Colorado-Kansas State line. It has a surface area of 2,296 acres when full, and 722 acres at low-water level. Water can be impounded to a depth of 23 feet, allowing a margin of 5.5 feet between the high-water line and the top of the embankment. The total available capacity is 32,557 acre-feet of water, while the unavailable capacity below the sill of the outlet sluice is 7,515 acre-feet. The reservoir is the lowest of four developed by the Great Plains Water Company, of Colorado, in the years 1898–99. The system is intended to supplement the water supplies of the Amity and Fort Lyon canals during the low stages of the Arkansas River.

The embankment in which the outlet is shown is 3,380 feet long. The maximum height at the outlet structure is 17 feet. It is 20 feet wide on top, with slopes of 1 on 1.5 on the outer and 1 on 2.5 on the inner or water side, which is riprapped with rock excavated from the connecting channel between the two basins. The riprapping is all hand laid and is from 18 to 24 inches in thickness. The embankment was constructed of earth from borrow pits within the reservoir and excavated from the outlet channel. The material is a fine loam, which when subjected to the tramping of men and teams becomes a very fine, loose powder. In this latter condition it was put into the embankment in 12-inch layers by drag and wheel scrapers. The settlement at the outlet structure after completion and before the reservoir was filled with water was scarcely apparent. When the reservoir was filled and water stood against the embankment to a depth of 8 feet considerable settlement was soon noticeable on the reservoir side, which increased slowly and gradually until uniform throughout the entire cross section. The total settlement at the outlet structure is nearly 2.25 feet.

For drainage purposes the top of the embankment was built with a decided dip or slope to the reservoir. There is a small drainage channel along the entire length of the embankment, just alongside the upper course of the riprapping, and at intervals of 100 feet wooden troughs connect with said channel for conducting rain water down the riprapped slope to the natural ground at the toe. Before the drainage channel and troughs were built furrows as deep as 6 feet were cut in the light material of the embankment in the course of an hour or two's rainfall.

Water is conducted from the reservoir for irrigation uses by the Pawnee Canal. The outlet channel within the reservoir, from low-water mark to the outlet structure, is 1,000 feet long, 12 feet wide on the bottom, and with side slopes of 1 on 1. At the intersection of the embankment with this channel the discharge valves, 3 in number, are located. These have 30-inch circular openings and are attached by bolts to the flanges of three 30-inch wrought-iron riveted pipes. The pipes are 18 feet long and discharge into an open-arched culvert. They are imbedded in brick and stone masonry laid in cement. The drawings show the general form of construction adopted. All exposed walls are rock-faced coursed work laid in cement. The backings of the main wall are of limestone. All foundations are of heavy sandstone blocks laid in trenches or in the excavations as the plans show.

The valves are of the open sluice-gate pattern and are operated by 30-inch pilot wheels, with bevel gearing and rising hollow iron stems 2.5 inch diameter, which slide through guides bolted to the face of the masonry wall.

There is masonry in the outlet structure as follows:

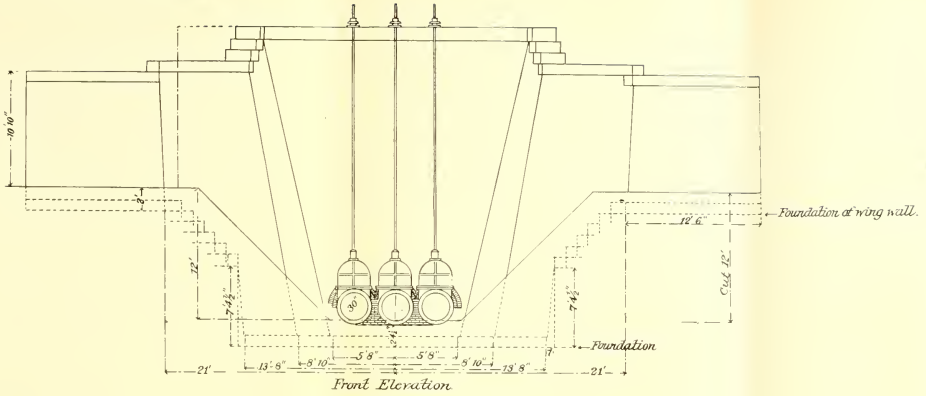
Brickwork	cubic yards	14
Limestone	do	110
Sandstone	do	375
Total		499

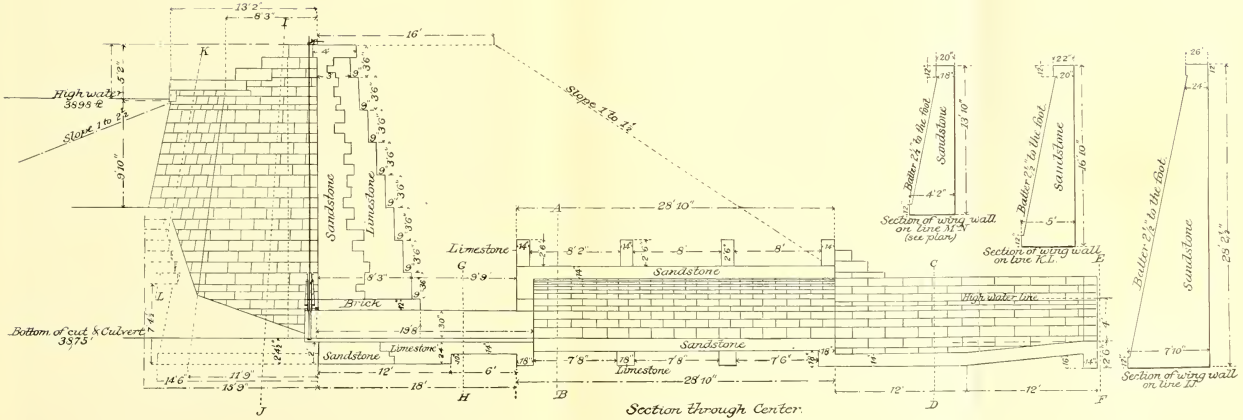
The total cost of the masonry was $8,350, or practically $16.75 per cubic yard. The sandstone was hauled a distance of 20 miles, and cost laid down at the works $3 per ton. Limestone was hauled a distance of 4 miles, and cost laid down at the works about $1.25 per ton. The sand was hauled from the Arkansas River. The total cost of the structure was $10,000. The rates of wages were:

Masons	per day	$3.50
Common labor	do	1.60

The cost of riprapping the embankment was $1.60 per square yard.

The outlet structure has proven a success in operation and has required very few repairs. With a full reservoir the seepage under the structure amounts to about 0.25 cubic foot per second. The engineer of the company believes a safer structure could have been built of concrete, in which the rock of the neighborhood could have been used, at from 20 to 25 per cent less cost. He does not mean to infer that the present structure is unsafe, but with a heavy concrete foundation in place of the heavy sandstone blocks fewer cracks due to unequal settlement would probably have resulted.





OUTLET GATES OF NEESKAH RESERVOIR, COLORADO.

GAGEBY ARROYO WASTE WAY, COLORADO.

[PLATES VII and VIII.]

Fort Lyon Canal crosses Gageby Arroyo waste way about a mile west of the point where water is diverted into the Kicking Bird Canal, the main supply canal of the reservoirs of the Arkansas Valley Sugar Beet and Irrigated Land Company. The capacity of the Fort Lyon Canal is 1,400 cubic feet per second. It crosses the arroyo on a level in earthen fill. Water runs in the arroyo only during rain storms, and the discharge gets as high as 6,000 cubic feet per second. The waste way was constructed in the spring of 1899, at a cost of $4,000, for the purpose of carrying the flood waters of the arroyo over the canal. During the freshet of 1900, through the inattention of the man in charge of the waste way, water overtopped the canal embankment. It cut along the west side of the structure and undermined it to some extent. Apart from this mishap, the waste way has given excellent service, has discharged as high as 5,000 cubic feet per second, and has been the means of avoiding several washouts.

The gates are hung from above and are held in position when closed by a post, one end of which rests in a recess in the frame of the gate and the other (the lower) against a hinged wrought-iron chair. This chair is tipped from the bridge over the waste way by a chain and crowbar. When open in times of discharge, the gates float on the surface of the water, and all can be tripped in three or four minutes.

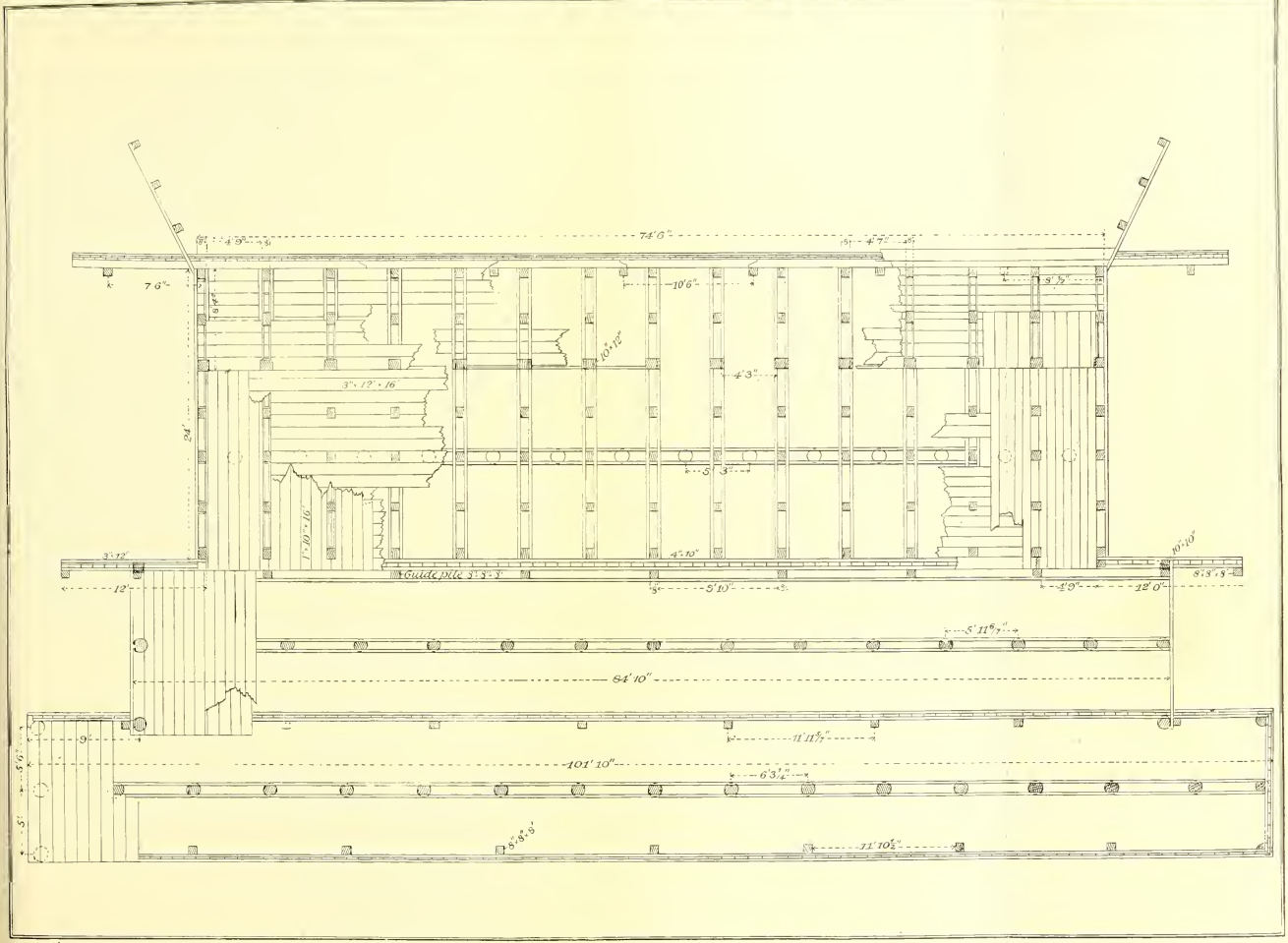
Materials cost as follows, f. o. b., at Las Animas:

Yellow pine lumber	per M..	$21.00
Native pine lumber	do....	16.00
Spruce piling	per foot..	.14
Nails	per keg..	2.75
Machine bolts	per 100 pounds..	3.00

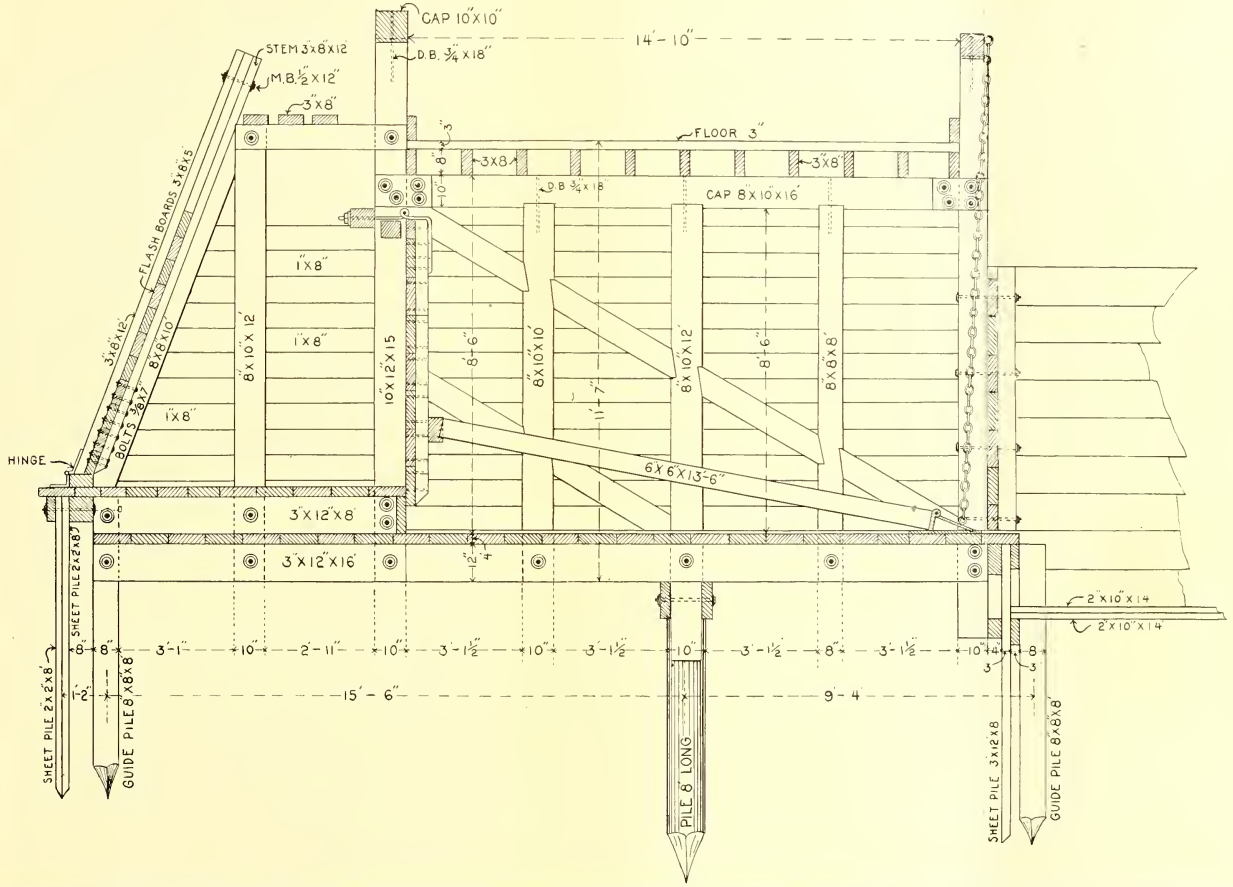
Labor cost as follows:

Carpenters	per day..	$2.50 and $3
Laborers	do....	1.60
Teams	do....	1.40

The cost covers excavations and back filling and rock for riprapping wings.



GAGEBY ARROYO WASTE WAY, COLORADO.

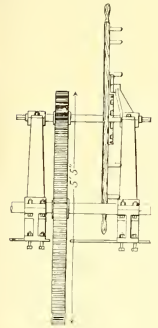


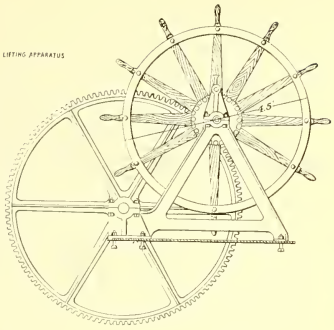
GAGEBY ARROYO WASTE WAY, COLORADO.

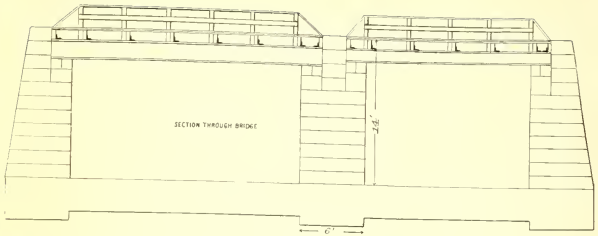
HEAD GATES OF GRAND VALLEY CANAL, COLORADO.

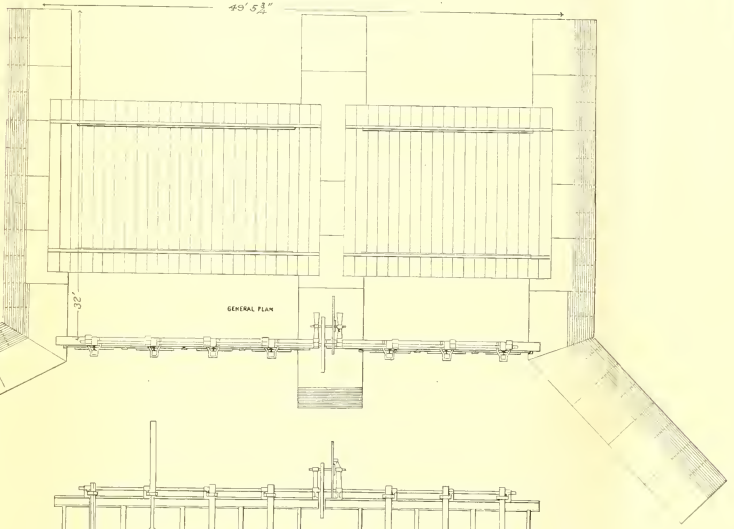
[PLATE IX.]

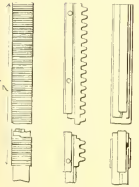
This head gate was constructed in 1901. It is intended to be operated against a pressure of 12 feet of water, and in exceptional floods water may run over the entire structure. The foundation of the gate is of cobblestones and no settlement has taken place. In practice one man can lift all of the gates at one time under the ordinary head of water, or a single gate under the maximum head of water. The cost was $13,500. The masonry cost $15 per cubic yard and lumber $18 per 1,000 feet B. M. The gates have proven entirely satisfactory in use. A shed has been built over them to protect the lifting gear, and they are painted each year

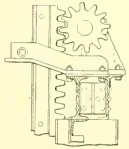


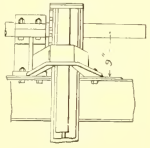


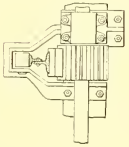






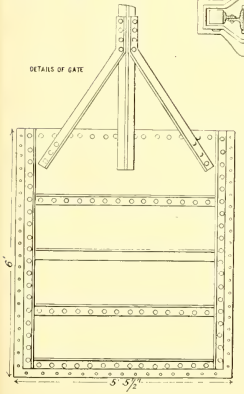


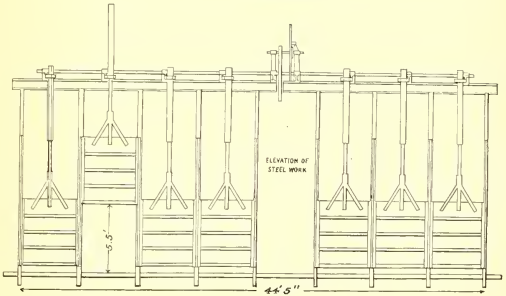




DETAILS AT RACK AND PINION

DETAILS OF GATE



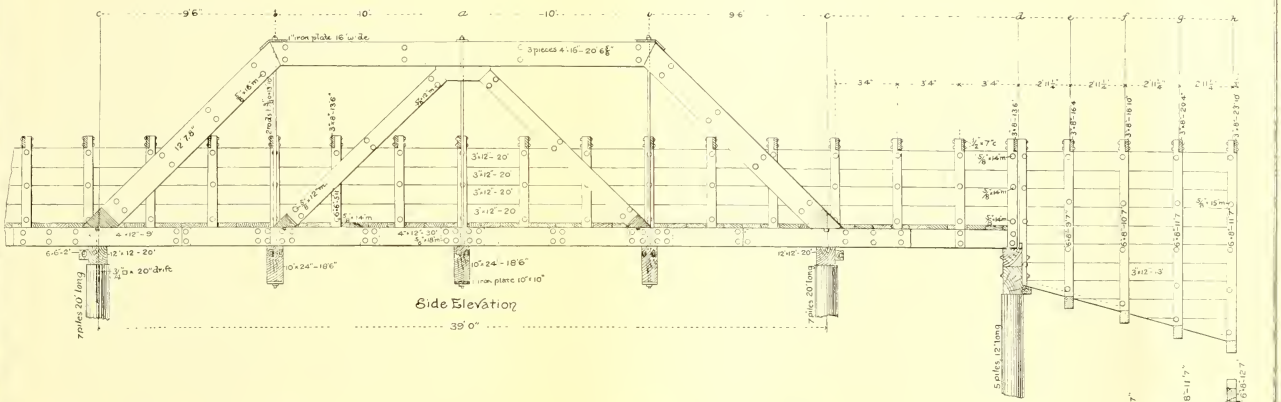


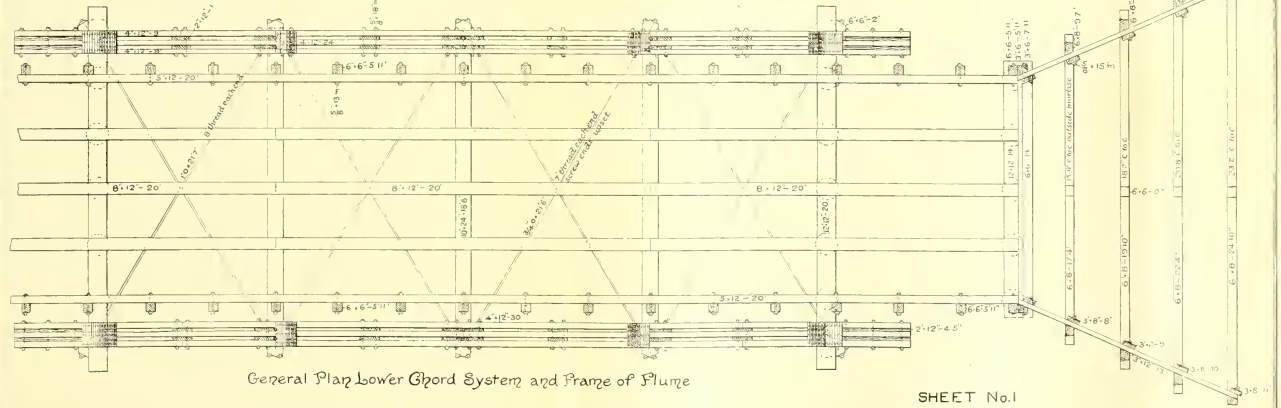
HEAD GATES OF GRAND VALLEY CANAL, COLORADO.

FLUME NO. 7, MAIN LINE GRAND VALLEY CANAL, COLORADO.

[PLATES X and XI.]

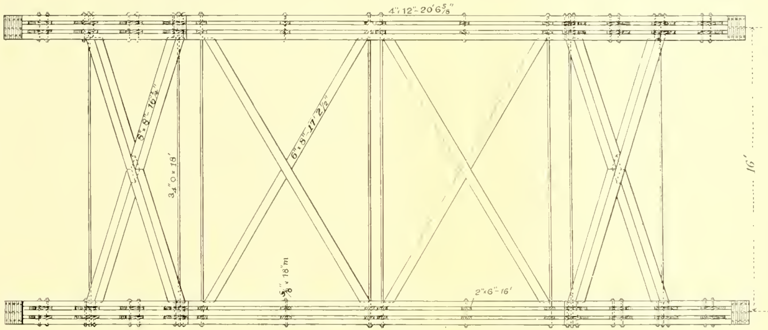
The bill of material which accompanies Plates X and XI, showing details of a flume on the Grand Valley Canal, gives full information regarding its construction. No reply has been received to the inquiry regarding the durability of these structures or the cost of material.





General Plan Lower Chord System and Frame of Flume

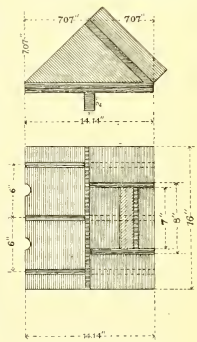
SHEET No. I



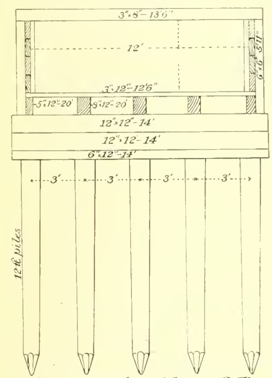
Plan Upper Chord & End Posts

Bill of Material
TRUSS
Lumber

No Pieces	Dimensions	ABM	Use in Structure	Location
4	4"×12"–18'	288	Lower chords	bet b&c and b'&c'
4	4"×12"–30'	480	" "	" c&c'
4	4"×12"–24'	384	" "	" "
6	4"×16"–22'	704	Upper "	" b " b'
6	4"×16"–26'	832	End posts	" b&c and b'&c'
2	12"×12"–20'	480	Caps	at c&c'
3	10"×24"–20'	1200	Floor beams	" a, b and b'
4	4"×10"–24'	320	Main braces	bet. a&b and a'&b'
1	6"×6"–8'	24	Blks for floor brace	at c & c'
10	2"×12"–16	320	Packing blocks	main members
1	2"×10"–10'	17	" "	" braces
4	6"×8"–18'	288	Upper Ch'd bracing	bet. b & b'
4	8"×8"–16'	341	End post "	" b&c and b'&c'
1	10"×16"–6	80	Head blocks	at a
Piles				
14	20' long 10" lesser dia		Foundation	at c&c'
Iron Work				
4	1 3/8" ○×13'10" rods		Suspension rods	at b & b'
2	1 1/8" ○×13'10" "		"	" a
6	3/4" ○×18' "		Upper Ch'd ties	" a, b and b'
2	3/4" ○×18' "		End post ties	bet. b&c and b'&c'
4	1" ○×21'7" "		Floor bracing	" " " "
4	3/4" ○×21'6" "		" "	" a, b, a', b'
Note All rods with thread, nuts and washers as shown on plans				
8	Shoes		Foot of posts	at b, c, b' & c'
4	1"×16"×18" plates		Conn Up Ch. & posts	" b & b'
2	1"×8"×16" "		at upper chord	" a
6	1"×10"×10" "		" floor beams	" a, b and b'
Bolts				
152	5/8"×18" machine		Ch'ds & end posts	throughout
24	5/8"×12" "		Chord bracing	between b & b'
14	3/4" □ 22" drift		Caps	at c & c'
Washers				
400	5/8" cast		for 5/8" bolts	throughout



Side Elevation & Plan Casting under Center Posts



Section at Connection of Apron with Flume.

Bill of Material
FLUME
Lumber

No Pieces	Dimensions	ABM	Use in Structure	Location
2	3"×8"–24'	96	Crossties	at h & h'
2	3"×8"–22'	88	"	" g " g'
2	3"×8"–20'	80	"	" f " f'
2	3"×8"–18'	72	"	" e " e'
19	3"×8"–14'	532	"	from d to d'
2	6"×8"–26'	208	Side posts	at h & h'
2	6"×8"–24'	192	" "	" g & g'
2	6"×8"–22'	176	" "	" f " f'
2	6"×8"–20'	160	" "	" e " e'
19	6"×6"–12'	684	" "	from d to d'
2	3"×6"–12'	36	Fillers	at d & d'
1	6"×6"–26'	78	Center posts	" h " h'
1	6"×6"–24'	72	" "	" g " g'
1	6"×6"–22'	66	" "	" f " f'
1	6"×6"–20'	60	"	" e " e'
4	12"×12"–14'	672	Sills	" d " d'
2	6"×6"–14'	84	"	" d " d'
2	6"×8"–18'	144	"	" e " e'
2	6"×8"–20'	160	"	" f " f'
2	6"×8"–24'	192	"	" g " g'
2	6"×8"–26'	208	"	" h " h'
2	6"×12"–14'	168	Pile caps	" d " d'
6	5"×12"–20'	600	Outside stringers	from d to d'
9	8"×12"–20'	1440	Inside "	" d " d'
2	3"×8"–22'	88	" cleats	at h & h'
2	3"×8"–20'	80	" "	" g & g'
2	3"×8"–18'	72	" "	" f & f'
2	3"×8"–16'	64	" "	" e & e'
2	3"×8"–14'	56	" "	" d " d'
10	3"×8"–16'	320	" "	from d to d'
2	3"×6"–16'	48	Outside "	at d & d'
2	3"×12"–12'	72	Ends of stringers	" d " d'
4	2"×12"–18'	144	Foot walk	from d to h & d' to h'
2	2"×12"–12'	48	" "	" " "
3	2"×12"–20'	120	" "	" d to d'
20	3"×12"–26'	1560	Sides	" d to h & d' to h'
24	3"×12"–20'	1440	"	" d to d'
22	3"×12"–26'	1716	Floor	" d to h & d' to h'
31	3"×12"–26'	2418	"	" d " d'
Piles				
10	12' long 10" lesser dia		Foundation	at d & d'
Bolts				
8	1/2"×13" carriage		Crossties	at d & d'
48	1/2"×7" "		"	from e to h & e' to h'
68	1/2"×7" "		"	" d to d'
72	5/8"×15" machine		Inside cleats	" e to h & e' to h'
16	5/8"×14" "		" "	at d & d'
114	5/8"×14" "		" "	from d to d'
8	5/8"×14" "		Outside "	at d & d'
8	5/8"×17" "		Sills	" "
76	5/8"×13" "		Posts	from "
14	5/8" □×16" drift		Sills	at "
20	5/8" □×20" "		Piles	" "
Washers				
250	1/2" wrought		for 1/2" bolts	
600	5/8" cast		" 5/8 "	
Nails				
300	60d cut steel			throughout

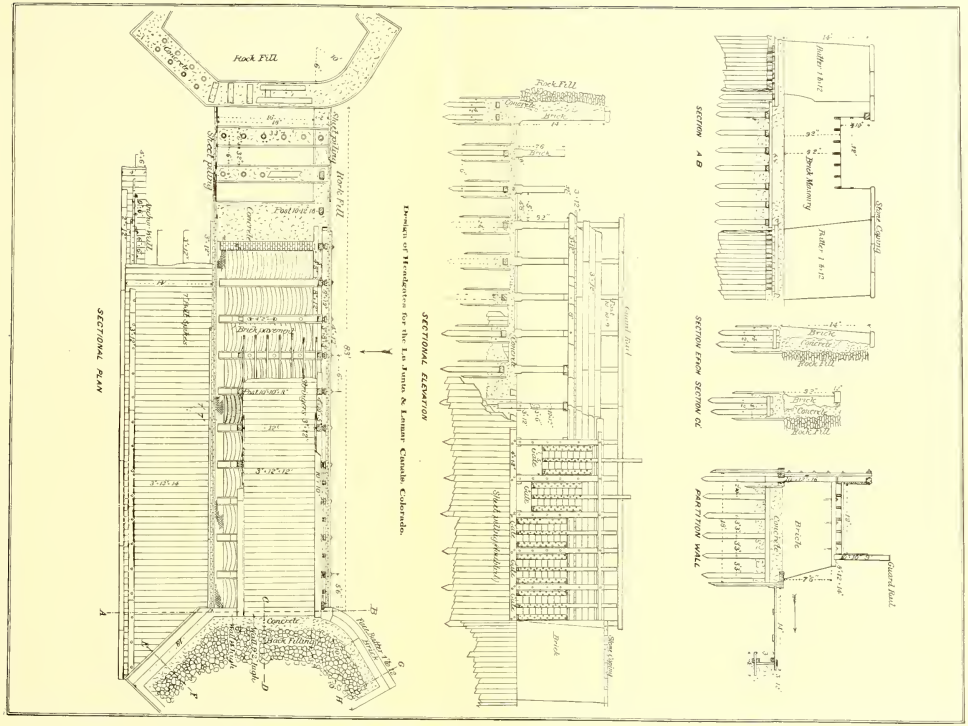
SHEET No. 2

FLUME No. 7, MAIN LINE GRAND VALLEY CANAL, COLORADO.

HEAD GATES OF LA JUNTA AND LAMAR CANALS, COLORADO.

[Plate XII.]

No report obtainable.

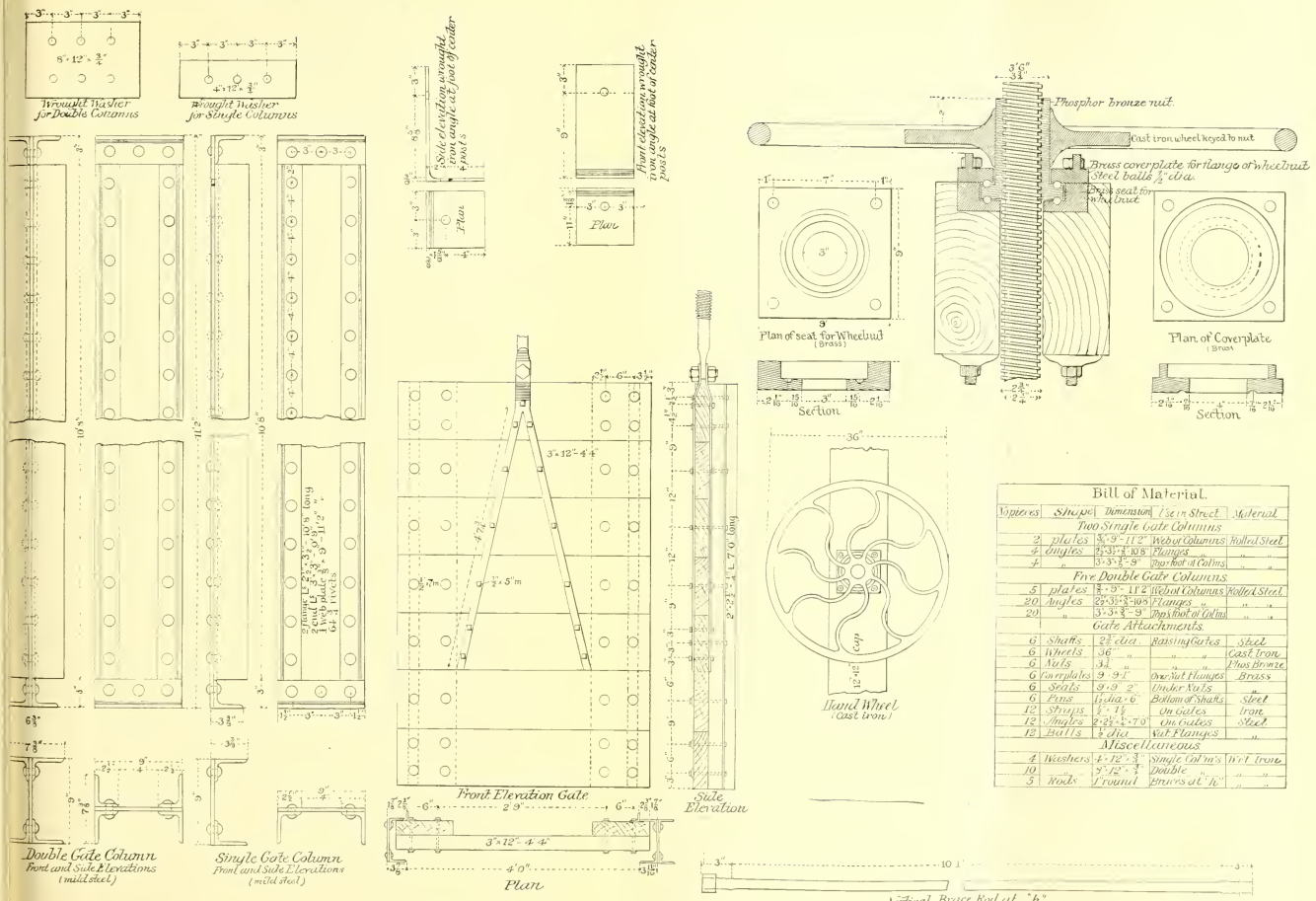


HEAD GATES OF LA JUNTA AND LAMAR CANALS, COLORADO.

HEAD GATES AND METAL WORK DETAILS OF MONTROSE CANAL, COLORADO.

[PLATE XIII.]

The details of the lifting apparatus of the Montrose Canal, Plate XIII, and the bill of material, show the design. This gate operates against a maximum head of water of 8 feet. It has been in use nineteen years and is still in good condition, none of the timberwork showing any serious impairment through decay.



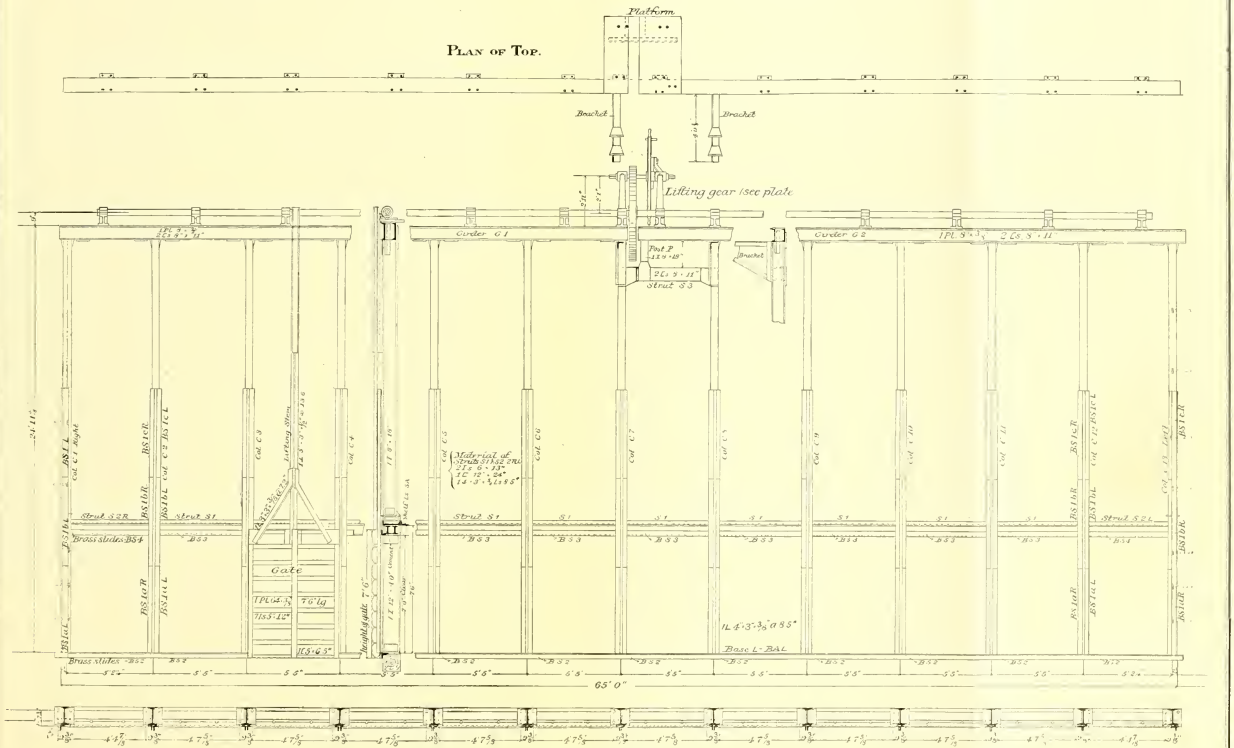
Bill of Material.

Numbers	Shape	Dimensions	Use in Struct.	Material
		Two Single Gate Columns		
2	plates	⅜"×9"-11'2"	Web of Columns	Rolled Steel
4	angles	2½×3½×⅜"-10'8"	Flanges	" "
4	"	3×3×⅜"-9"	Top Foot of Colms	" "
		Five Double Gate Columns.		
5	plates	⅜"×9"-11'2"	Web of Columns	Rolled Steel
20	Angles	2½×3½×⅜"-10'8"	Flanges	" "
20	"	3×3×⅜"-9"	Top Foot of Colms	" "
		Gate Attachments.		
6	Shafts	2½" dia	Raising Gates	Steel
6	Wheels	36" "	" "	Cast Iron
6	Nuts	3¼ "	" "	Phos Bronze
6	Coverplates	9 9-1"	One Nut Flanges	Brass
6	Seats	9-9 2"	Under Nuts	"
6	Pins	Tig dia 6"	Bottom of Shafts	Steel
12	Shrups	½" 1½"	On Gates	Iron
12	Angles	2½×2½×½×7'0	On Gates	Steel
12	Bolts	½" dia	Nut Flanges	"
		Miscellaneous		
4	Washers	4-12-¾"	Single Col'ms	Wrt Iron
10	"	4-12-¾"	Double	" "
5	Rods	1" round	Braces at "h"	" "

HEAD GATES AND LIFTING APPARATUS OF SONORA AND SINALOA CANALS, MEXICO.

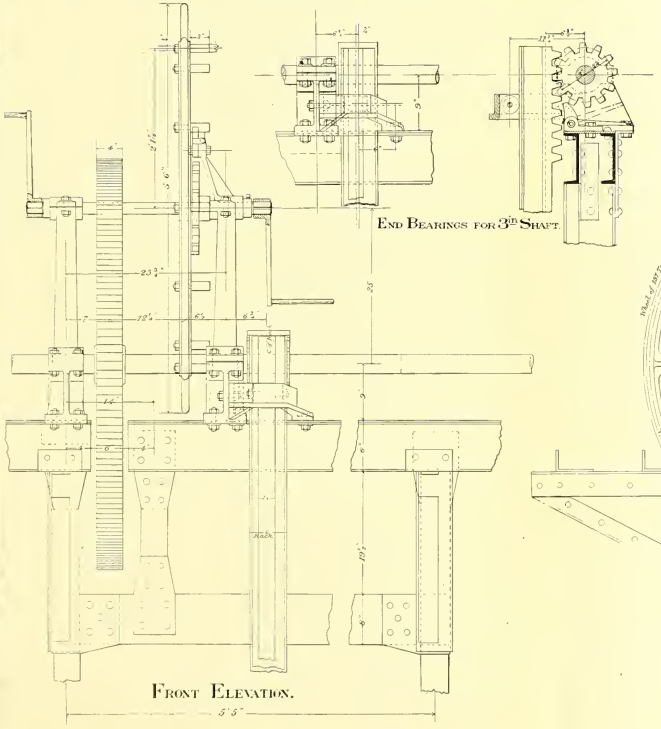
[PLATES XIV and XV.]

The head gates of the Sonora and Sinaloa canals, shown in Plates XIV and XV, were built in Pittsburg and shipped from there to Guaymas, Mexico, transported up the Yaqui River to Medano, and hauled from there in wagons 75 miles, the cost of transportation about doubling the original cost of the material. These structures are intended to withstand a pressure of 27 feet, and have a lifting device which will permit one man to operate the gates under this pressure. The total cost of the work was about $30,000.



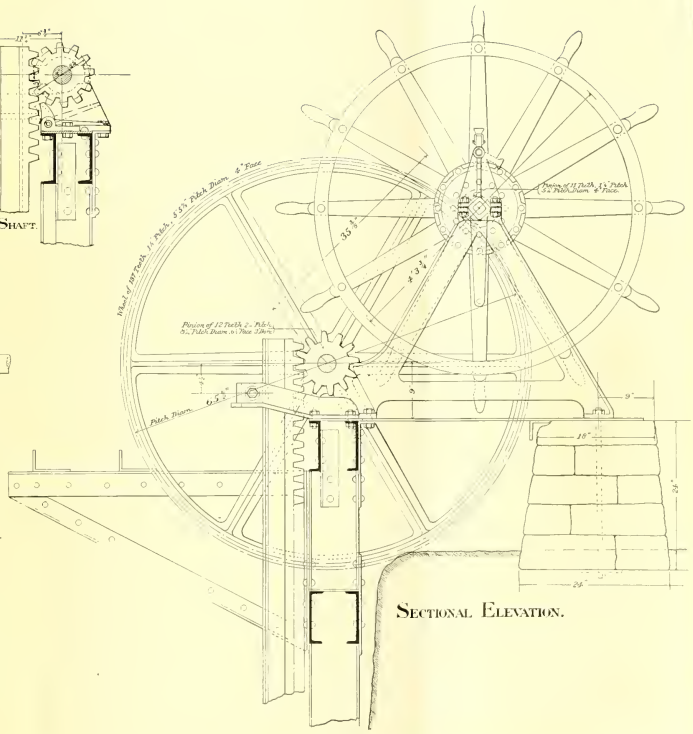
PLAN OF TOP.

PLAN OF BOTTOM.



FRONT ELEVATION.

END BEARINGS FOR 3IN SHAFT.



SECTIONAL ELEVATION.

LIFTING APPARATUS FOR THE HEAD GATES OF SONORA AND SINALOA CANALS, MEXICO.

OUTLET GATES OF McMILLAN RESERVOIR, CARLSBAD, NEW MEXICO.

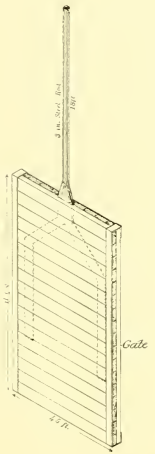
[Plate XVI.]

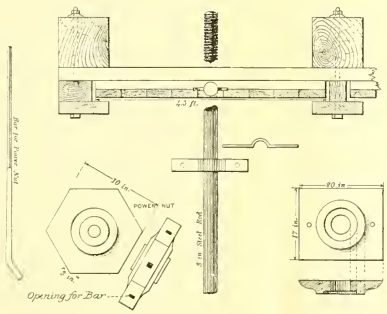
The main canal of the Pecos Irrigation and Improvement Company is supplied during a part of the year from the McMillan Reservoir by means of the structure shown in Plate XVI. This design is interesting because of the use of wooden gates and the heavy pressure to which they are subjected. The gates in this structure are 4½ by 8½ feet, the aperture being more than 32 square feet. The reservoir is intended to hold water to a depth of 30 feet, but the greatest depth of water against these gates of which there is any record is 23 feet 3 inches. At that time the lifting apparatus was without ball bearings and could be operated only with great difficulty. Since ball bearings have been put in, one man has handled the gates when the water stood 20 feet 4 inches in front of them. These gates were built in 1893, and water flowed down for filling the reservoir on December 28 of that year. The 12 by 12 timbers are still in good condition, being practically as strong as new. The 8 by 12 braces show signs of decay, and the 2-inch planking where exposed to earth or air is rotting badly, but where kept constantly wet is in good condition.

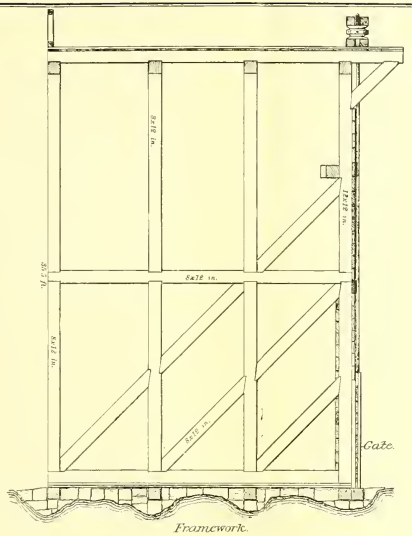
The total cost of the gates was about $20,000, with lumber at $32 per 1,000 feet B. M., skilled labor from $3 to $4.50 per day, common labor $1.50 to $1.75. The work was done by the company and not by contract. These gates were constructed of Texas pine, which timber, if cut from the center or heart, has been found here to be exceedingly durable, more so than oak. But the sap part decays rapidly, and this no doubt accounts for the poor condition of the 8 by 12 timbers, probably cut from the outside of the stick. All the masonry in gate walls and elsewhere is in fine condition, and apparently the gates, as a whole, are still in good condition to stand the pressure of 17 feet 6 inches constant and occasional greater pressure for shorter periods.

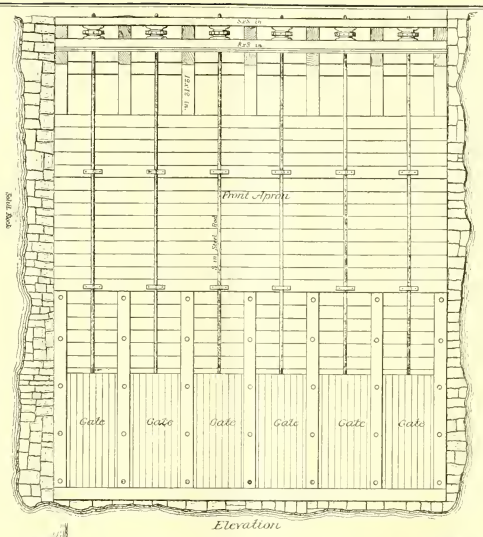
In reply to a letter of inquiry the manager of this company says:

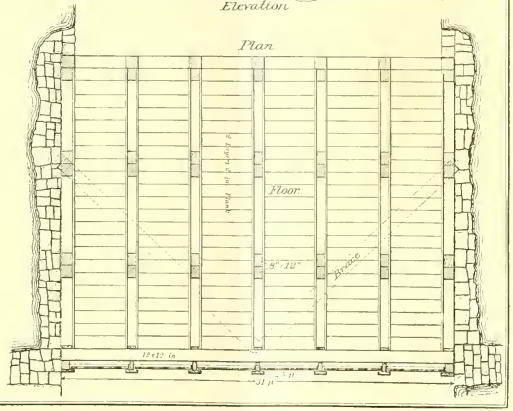
> Our experience leads us to believe that wherever material for concrete can be obtained it is unwise to use timber in irrigating laterals, head gates, dividing boxes, etc., or anywhere that concrete can be used, unless lumber is very cheap. We shall hereafter use concrete everywhere it can be done, and are now constructing a concrete aqueduct to replace our old wooden flume, with a capacity of 1,500 cubic feet per second.











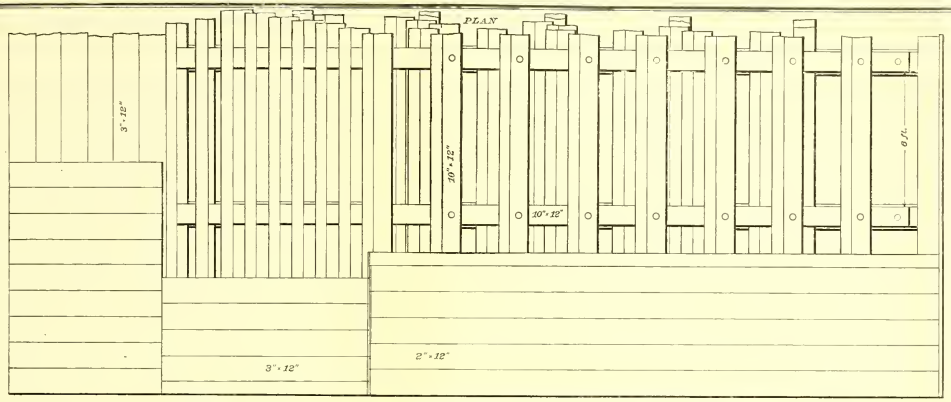
OUTLET GATES OF McMILLAN RESERVOIR, CARLSBAD, NEW MEXICO.

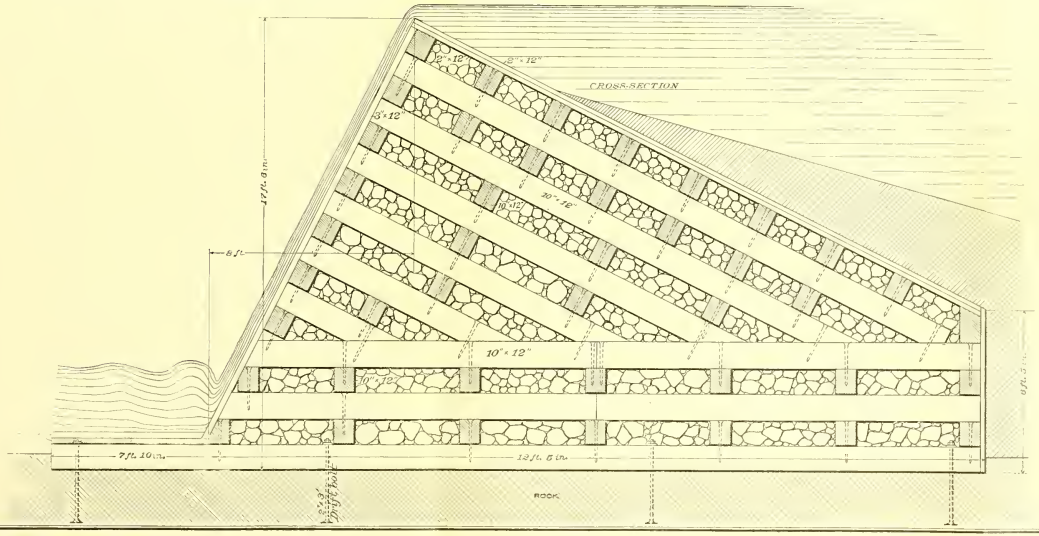
DAM OF BEAR RIVER CANAL, UTAH.

[PLATE XVII.]

Bear River Canal diverts 1,000 cubic feet of water per second from Bear River in a canal 10 feet deep. The dam shown in Plate XVII is a diversion weir built across the river at the head gates of the canal to maintain the requisite depth in the canal when the river is low. The total height is 17 feet 6 inches, and it has to withstand a flood discharge of 15,000 or 20,000 cubic feet per second. The plan shows the character of construction and the method of anchoring the weir to the solid rock of the river channel. The timber used in this dam cost $22,000; nails, $5 per hundredweight; bolts, $5.75 per hundredweight. The total cost of the dam was $45,000. The dam was built in 1890, and the timbers have rotted considerably. Several had to be replaced in 1902.

Plan



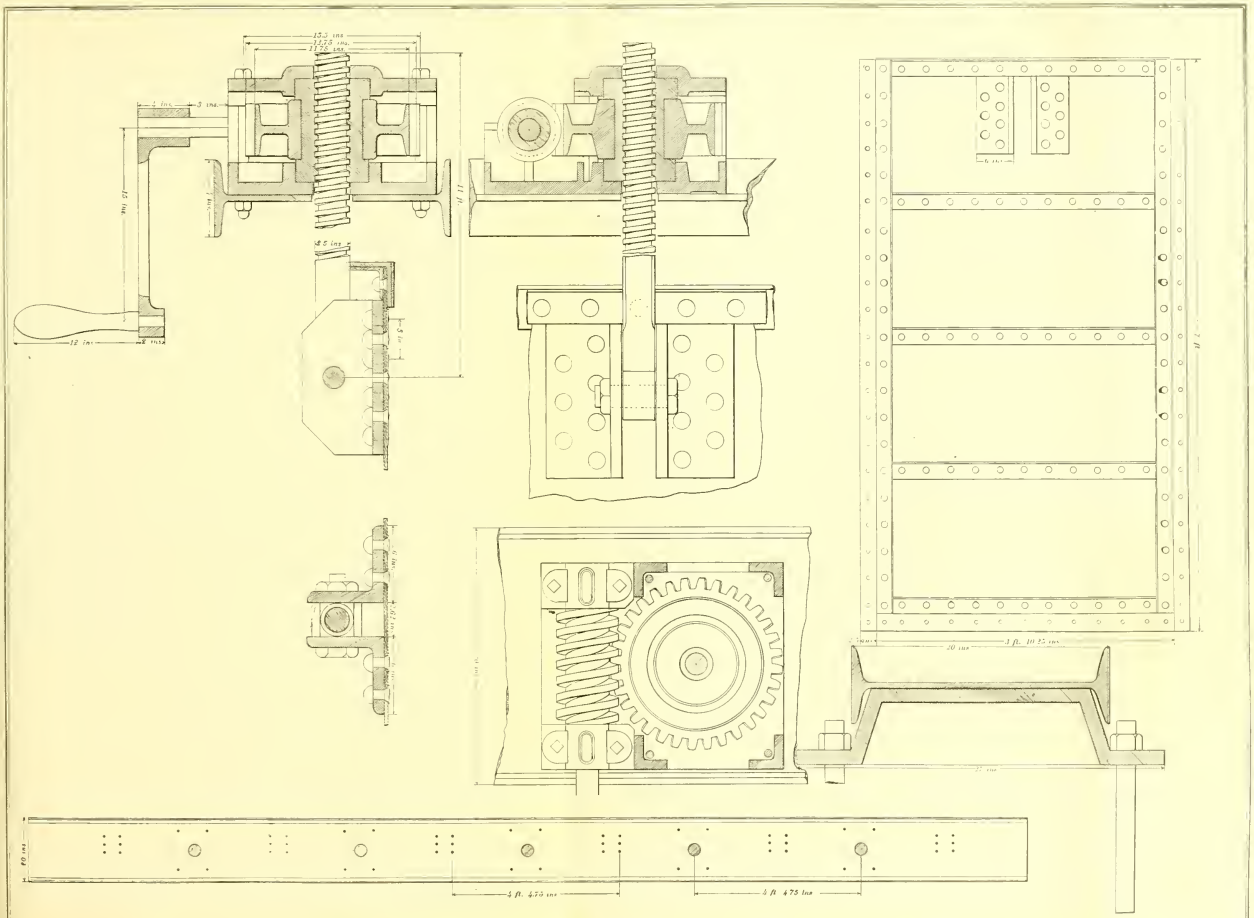


DAM OF BEAR RIVER CANAL, UTAH.

LIFTING APPARATUS FOR HEAD GATES OF THE BEAR RIVER CANAL, UTAH.

[PLATE XVIII.]

The lifting apparatus of the gates of the Bear River Canal, shown in Plate XVIII, was designed to enable one man to raise and lower gates having a clear aperture of 21 feet against a pressure of 20 feet. The gate structure is all iron. It rests upon a concrete foundation 3 feet thick, the thickness being due to the fact that the gates rest upon a mud foundation. The gates have been in use since 1890. They have required no repairs, and are in good condition at present.

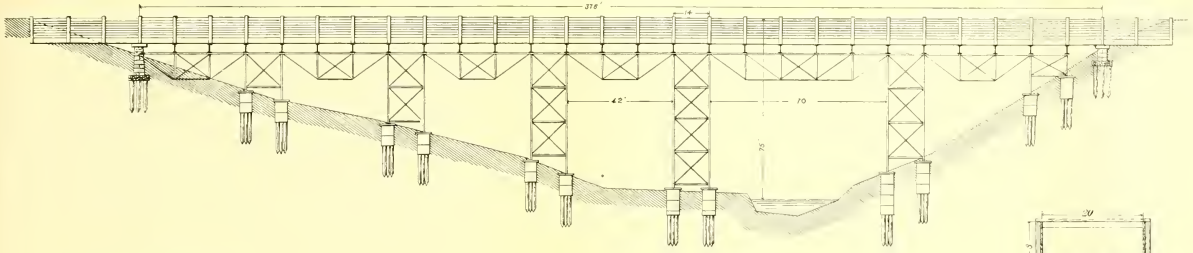


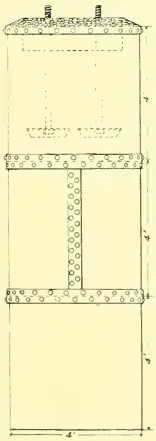
LIFTING APPARATUS FOR HEAD GATES OF THE BEAR RIVER CANAL, UTAH.

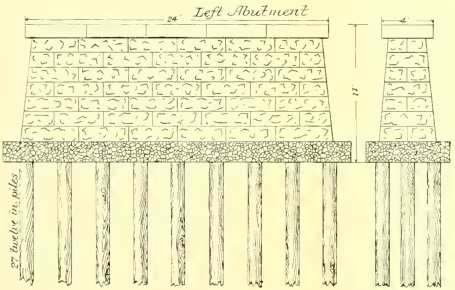
AQUEDUCT OVER MALADE RIVER, BEAR RIVER CANAL, UTAH.

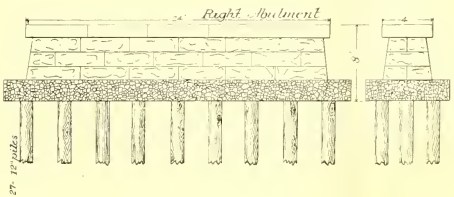
[PLATE XIX.]

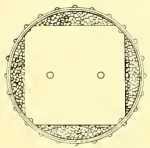
The aqueduct shown in Plate XIX carries the water of Bear River Canal over the Malade River. This crossing was a difficult one, owing to the steep bank on the east side and to the uncertain foundations on either side of the river. Floods have twice filled the flume to overflowing, but no damage has resulted. The total cost of this structure was $3,900. It was built in 1890 and is still in perfect condition. Rust of the iron work has been prevented by keeping it painted.

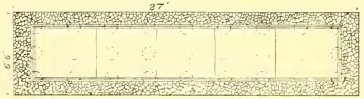










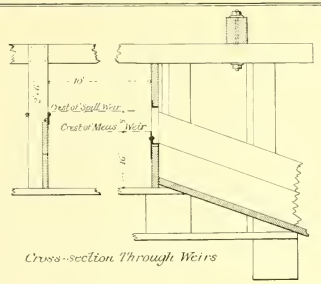


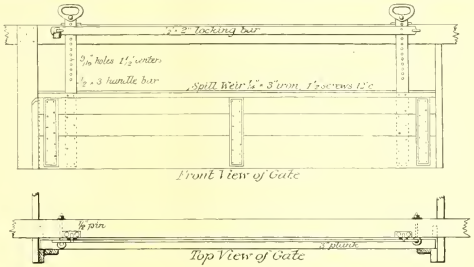
AQUEDUCT OVER MALADE RIVER, BEAR RIVER CANAL, UTAH.

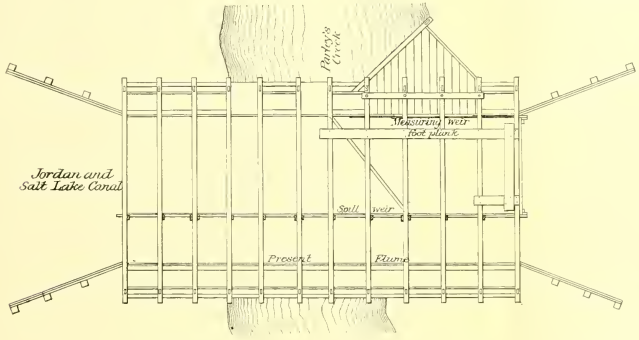
WEIR FOR MEASURING WATER FURNISHED BY JORDAN AND SALT LAKE CITY CANAL IN EXCHANGE FOR WATER OF PARLEYS CREEK, UTAH.

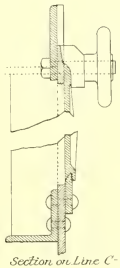
[PLATE XX.]

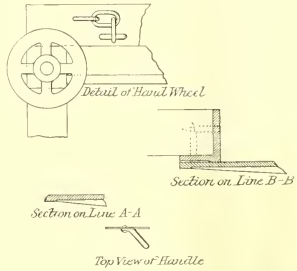
No report obtainable.

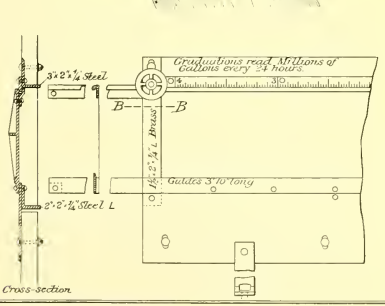


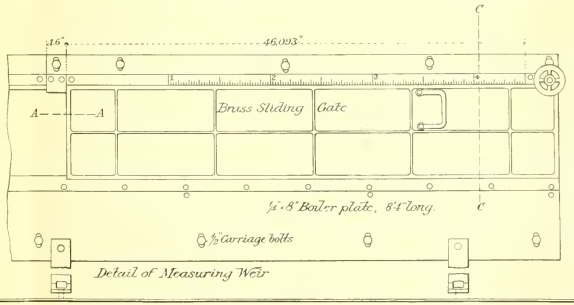


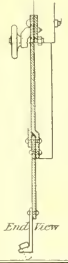












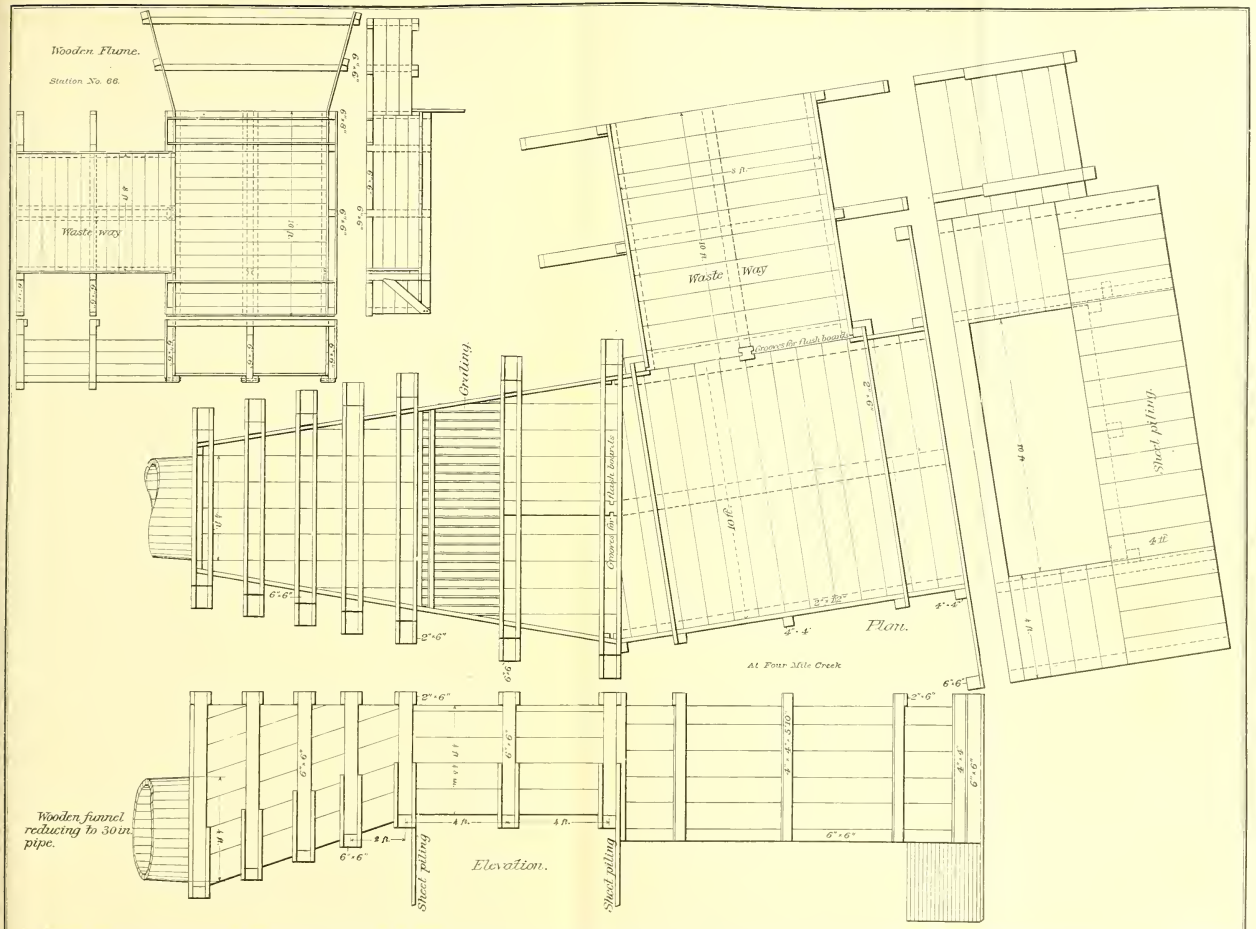
WEIR FOR MEASURING WATER FURNISHED BY JORDAN AND SALT LAKE CITY CANAL IN EXCHANGE FOR WATER OF PARLEYS CREEK, UTAH.

PENSTOCK AND WASTE WAY OF WEST SIDE CANAL, WYOMING AND COLORADO.

[PLATE XXI.]

Plate XXI shows the inlet and outlet boxes of a wooden stave pipe which is intended to carry the water of the West Side Canal across a creek valley which at its lowest point is 95 feet below the grade of the ditch. To have followed up one side of this creek valley to a grade crossing and then down on the other side would have involved the construction of about 10 miles of canal. This was avoided by building an inverted siphon of wooden pipe 4,000 feet in length directly across the valley. The slopes on both sides of the valley were quite steep, one being nearly 30°; hence connection between the pipe line and the earth canal had to be looked after carefully in order that dangerous leaks might be prevented. Where the pipe enters the wooden box the end projects 2 feet inside, and this space is surrounded by earth tightly rammed. In the nine years since its construction there have been no breaks in this nor in two other similar pipe connections on this canal.

The structure was built in 1894, and is still in use, although some of the timbers show signs of decay. Lumber and dimension timbers cost $15 per 1,000 feet B. M., delivered along the canal. The wooden pipe cost complete in place, including trenching and refilling, $2.20 per linear foot.



PENSTOCK AND WASTE WAY OF WEST SIDE CANAL, WYOMING AND COLORADO.

LAYBOURN IRON FLUME.

[PLATE XXII.]

No report obtainable

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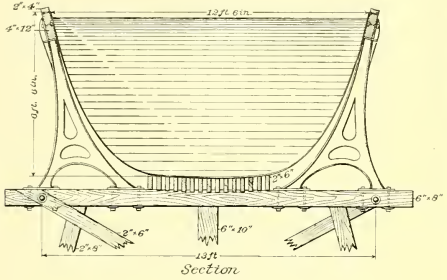
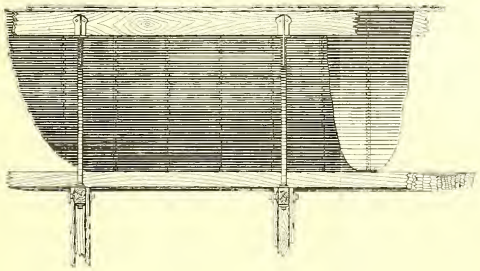
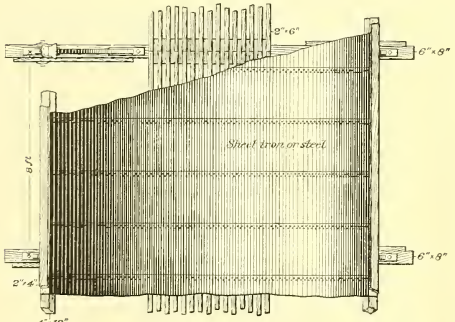
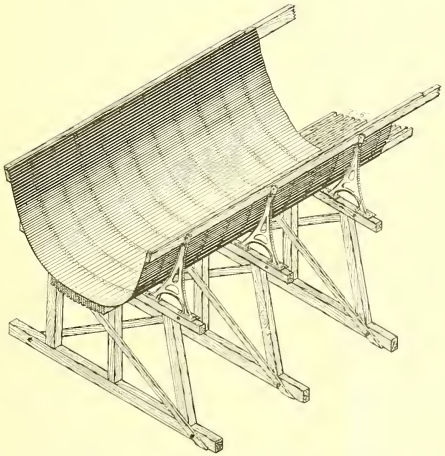


Section





Plan



LAYBOURN IRON FLUME.